Breeding Goal and Selection Criteria of Smallholder Farmers for Crossbred Dairy Cattle in Central Ethiopia

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Abstract: The aim of this study was to determine the breeding goal, selection criteria, traits preference and relative weight of selected traits required for genetic improvement of smallholder dairy cattle in the selected districts of West Shewa, North Shewa and Arsi Zone of Oromia Region and North Shewa Zone of Amhara Region. The data were collected through a pre-tested questionnaire and group discussions partaking 243 farmers who had crossbred dairy cattle. Chi-square and GLM procedure of the Statistical Analysis System was used to estimate and compare qualitative and quantitative data, respectively. The main sources of crossbred dairy cattle for foundation stock were local market (29.63%), surrounding farmers (25.51%) and crossing local cows and heifer with bull and artificial insemination (20.16%). The primary objective of farmers for rearing crossbred cattle was milk production (index = 0.5) followed by draught (index = 0.26) and beef (index = 0.24). The average herd sizes of indigenous and crossbred cattle were 2.02±0.14 and 6.89±0.24 heads per farmer, respectively. Significantly higher proportion ($p < 0.0001$) of farmers (75.52%) choose dairy as the primary goal and the other 24.48% favor dual purpose for future genetic enhancement. There was no significant difference ($p > 0.05$) observed among study Zones on breeding goal preference. The least square means and standard error of daily milk yield, age at first calving and calving interval performances of crossbred dairy cattle under farmer management were 11.28±0.24 liters, 2.96±0.04 years and 1.32±0.02 years, respectively. Farmers provided the highest weight for milk yield (28.13±1.04%) followed by body conformation (20.07±0.87%) and udder size and set up (18.73±0.90%) as selection criteria to purchase or select crossbred dairy cattle. The average weight provided for milk yield, calf growth, age at first calving, calving interval and herd life traits were 29.73±1.51%, 18.53±0.66%, 17.80±0.93%, 19.60±1.47% and 14.40±1.18%, respectively. In general, farmers were encouraged with the performance of crossbred cattle and noticeably reducing the number of indigenous cattle. The result can point out that majority of farmers across all study Zones provide more attention for dairy traits than beef. Moreover, most of them had a similar perception on the relative importance of different traits indicating the possibility to develop a similar breeding program through the study areas. In designing a breeding program in the future, the weight given for each trait in this study need to be considered. Improvement of artificial insemination service, access to marketing of crossbred cattle and design of appropriate breeding programs are essential for the development of this sector in the future.

Keywords: *Breeding goal, Selection criteria, Traits preference*

Introduction

Crossbreeding has been used as the main tool for the genetic improvement of dairy cattle in the central part of Ethiopia (EIAR, 2017; MOA, 2019). Crossbred cows produce about 5kg more milk yield per day and attain the age at first calving one year earlier than indigenous cows (Kefena *et al*., 2006; Zelalem *et al*., 2006; Million *et al*., 2010). The nutritional and economic contribution of crossbred dairy cattle for smallholder farmers is also substantial (Mohamed *et al.,* 2004; Roschinsky *et al*., 2015). For instance, Agajie *et al.* (2016) studied that those smallholder farmers who adopted crossbred dairy cattle generated about 40% more income than non-adopters. However, crossbreeding practices were not supported by breeding programs which is vital to reduce fluctuation in performance and adaptation problems across generations for the sustainability of the business. A Breeding program is a designed structure that targets to genetically improve the livestock population and bring substantial change to the farming community and the country (FAO, 2010; Philipsson *et al*., 2010). Hence, institutes working on dairy cattle development and research in Ethiopia have provided special attention in their strategic documents to design and implement an appropriate breeding program in the next 15 years (EIAR, 2017; MOA, 2019). The primary task in the design of a breeding program is setting up of breeding goal. Participation of farmers in setting a breeding goal,

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traits preference and economic weight of the traits is crucial for the practical implementation and success of the breeding program (Zewdu *et al.,* 2006; Solkner *et al*., 2008; Tesfaye *et al*., 2010; Traore *et al*., 2016; Direba, 2018). There is limited information on breeding goals, traits preference and importance weight of the traits for crossbred dairy cattle generated from the rural area in recent years in Ethiopia. Therefore, the aim of this study was to determine the breeding goal, selection criteria, traits preference and relative weight of selected traits for genetic improvement of smallholder dairy cattle in the selected dairy niches.

Materials and Methods

Study Areas

The study was conducted in the selected districts of Arsi Zone, West Shewa Zone, North Shewa Zone of Oromia Region (NSHORO) and North Shewa Zone of Amhara Region (NSHAMA). Study Zones were selected purposively because they have huge cattle population with an estimated 7,958,831 heads of cattle (2,253,959 for West Shewa, 1,676,748 for NSHORO, 2,545,778 for Arsi and 1,482,346 for NSHAMA) (CSA, 2017). Furthermore, it is the most common area where crossbreeding has been widely practiced during the last three to four decades. Out of the 1,073,093 head of crossbred cattle population in Ethiopia, about 35.2 percent are found in these four Zones (CSA, 2017). The climate of the area is favorable for dairy production and the districts have good access to input and output supplies since they are located within 20 to 150 km on the main road to Addis Ababa. Two districts practicing crossbreeding were selected from each zone. The selected districts were Welmera and Ambo (West Shewa), Girar Jarso and Waachale (NSHORO), Debrebrehan Zurya and Angolalla Tera (NSHAMA), and Tiyo and Limu Bilbilo districts (Arsi). Two accessible *kebeles* (from different directions and not neighboring one another) were chosen randomly from each selected district.

Arsi Zone is located between 7°08'58"N to 8°49'00"N latitude and 38°41'55"E to 40°43'56"E longitude. The altitude of this Zone ranges from 1500 to 4245 meters above sea level (m.a.s.l). The mean annual temperature is between 10°C to 25°C and the annual rainfall varies from 700 to 1400 mm (Tolesa, 2014). Debre Birhan (the capital town of NSHAMA) is sited in between 9°36'N latitude and 39°38'E longitude with an altitude of 2780 m.a.s.l. The annual rainfall of the area was 1060 mm and the average annual minimum and maximum temperatures were 6°C and 22°C, respectively (Gebremedhn *et al*., 2015). North Shewa Zone of Oromia Regional state is situated between 9°05"N and 10°23"N latitude and 37°57"E and 39°28"E longitude. This Zone has an altitude between 500 and 3541 m.a.s.l. The mean annual rainfall ranges from 600-2000 mm, while the mean annual temperature varies between 10°C-25°C (Mosisa *et al*., 2020). West Shewa Zone is located between 8°17"N to 9°60"N latitude and 37°17"E to 38°45'E longitude. The area is located at an altitude ranging from 1000 to 3500 m.a.s.l with an annual rainfall of 1300-1700 mm. The mean annual temperature ranges from 23-25°C (PSEP, 2011).

Data Collection and Analysis

The data were collected through a pre-tested questionnaire and group discussions. Individual farmers were asked about cattle herd size and structure, the purpose of keeping cattle, breeding goal, mating system, and performance of their crossbred cattle. According to the information obtained from the district dairy development office and the *kebele* development agent, there were about 50 households that keep crossbred dairy cattle per *kebele*. A total of 15 dairy farmers, representing about 30% of farmers keeping crossbred cattle, were randomly selected from a list of such farmers in each *kebele* (58 to 63 households from each zone) for interview. The selection was based on the N/n interval method, where, N= total households who have crossbred cattle and n= sample size required (Kothari, 2004).

Farmers' group discussion (FGD) method was also used to obtain information on the breeding objective of farmers for keeping indigenous and crossbred cattle, and the weight of importance of different traits and selection criteria for bull and cows. A total of 15 FGD (3-4 FGD per zone) were undertaken and about 8-12 farmers participated in each FGD (*kebele*). Thus, the proposed selection criteria and dairy traits were weighted out of a hundred at each FGD. The mean and associated standard error of importance weight provided for each selection criteria and dairy traits, and their difference across study Zones was estimated with the following model using GLM procedure of the Statistical Analysis System (SAS, version 9; 2002).

$$Y_i = \mu + K_i + e_i$$

Where, Y_i represent weight given by FGD for selection criteria (milk yield, conformation, tail, udder for cows/scrotum for bull, color and temperament) or dairy traits (milk yield, calving interval, age at first calving, calf growth and herd life); μ is the overall mean; K_i is the fixed effect of i^{th} zones; e_i is the random residual term.

The breeding objectives and reason to prefer and keep crossbred were ranked based on Indices as Index = Sum of (for instance for the parameter that has 4 options to be ranked, 4 times rank 1 + 3 times rank 2 + 2 times rank 3 + 1 times rank 4) given for an individual reason divided by the sum of (4 times rank 1 + 3 times rank 2 + 2 times rank 3 + 1 times rank 4) for overall reasons (Kosgey, 2004).

Analyses of the proportion of age and education status of respondents, herd structure, sources of crossbred dairy cattle for foundation stock, farmers' access and preference for breeding techniques and breeding goal of farmers were carried out using the chi-square test (SAS, version 9; 2002). In addition, the GLM procedure of the Statistical Analysis System (SAS, version 9; 2002) was used to estimate the

performance of crossbred cattle under farmers' management conditions. The daily milk yield (DMY), calving interval (CI) and age at first calving (AFC) performance of crossbred and effect of zones on these traits were estimated using the following model.

$$Y_i = \mu + G_i + e_i$$

Where, Y_i represents performances for DMY, CI and AFC; μ is the overall mean; G_i is the fixed effect of i^{th} zones; e_i is the random residual term.

Results and Discussion

Household Characteristics

Out of 243 sampled households, 71.2% were male and 28.8% were female. This is consistent with the report of Agajie *et al.* (2016) in the Oromia Region, Ethiopia; Belay and Janssens (2016) in Jimma; Azage (2004) in Addis Ababa; and Yitaye (2008) in north-western part of Ethiopia. The higher proportion of male respondents might be attributed to population distribution (low number of divorced and widow females compared to those married) and culture of the society (husband is considered as head to represent the family for a survey). As shown in Table 1, the average family size was 5.98±0.13 and similar to the value (6) estimated by Dehinenet *et al.* (2014) and Abebe *et al.* (2014) for dairy farmers in central and southern Ethiopia, respectively. However, it is lower than the report of Kibru *et al.* (2015) who found 7 persons per household in Aleta Chuko district in Southern Ethiopia. The result revealed that family size was significantly higher ($p < 0.001$) in West Shewa (6.62±0.26) and NSHORO (6.27±0.26) than Arsi (5.89±0.25) and NSHAMA (5.21±0.25). The average age of the respondents was 43.23 years and the majority of the respondents (73.66%) were between 31 to 50 years of age (Figure 1). The education status of the respondents showed that about 29.63%, 27.57% and 14.81% learned upper primary (5-8), secondary education (9-12) and lower primary (1-4), respectively (Figure 1). This implies that more than 70% of farmers can record data for breed evaluation and selection if trained and participated in the breeding program.

Table 1. Average family size and standard error of the households across the study Zones

Zones	N	Family size*
Arsi	62	5.89±0.25^{bc}
NSHAMA	63	5.21±0.25^{c}
NSHORO	60	6.27±0.26^{ab}
West Shewa	58	6.62±0.26^{a}
Overall mean	243	5.98±0.13

*N= Number of observations; NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; * indicates $p < 0.001$; Least squares means with the same superscript indicate non-significance ($p > 0.05$) between zones.*

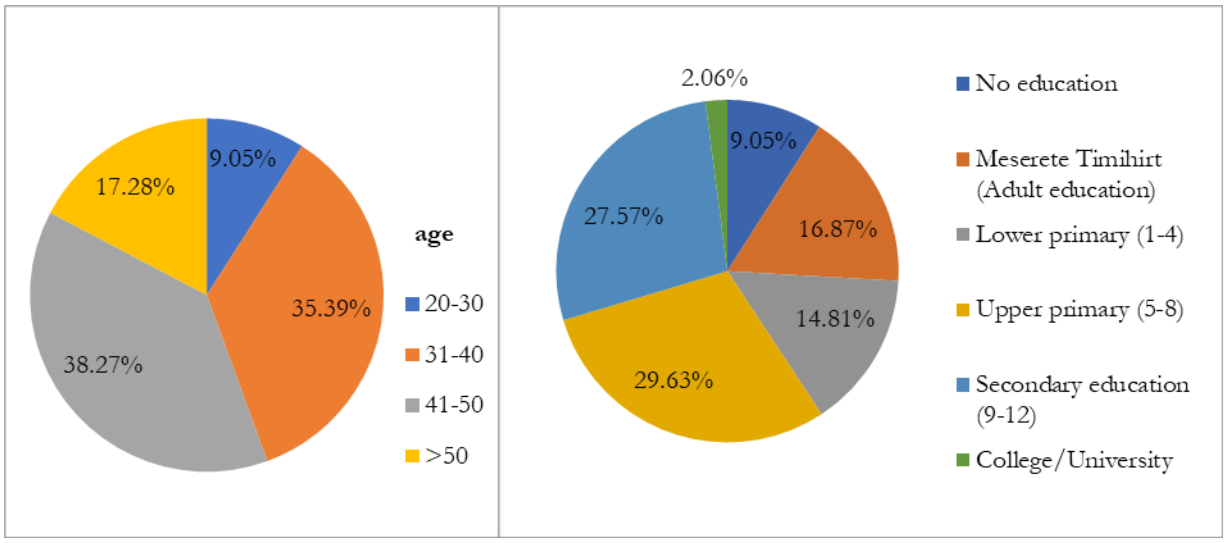

Figure 1. Proportion (%) of age and education status of respondents (number of observations = 243).

Sources of Crossbred Dairy Cattle for Foundation Stock

Table 2 summarized the sources of crossbred dairy cattle for foundation stock in the rural and peri-urban areas. The genotype and blood level of studied crossbred dairy cattle was not identified by this study because of the lack of pedigree records at the smallholder level. The main sources of crossbred dairy cattle to start dairy farming were the local market (29.63%), the surrounding farmers (25.51%) and the crossing of local cows and heifers with bulls and artificial insemination (20.16%). Thus, from sampled households, more than half of farmers started rearing crossbred cattle through purchasing, and the contribution of government and non-governmental organizations is less than 20 percent. Destalem *et al.*

(2015) noted that about 69% of households in central Tigray, Ethiopia started crossbred dairy cattle farming through purchasing. Bebe *et al.* (2003) and Belay and Janssens (2016) have also studied that the majority of households (83% and 93%) purchase crossbred cattle for foundation stock in the Kenyan highlands and the western part of Ethiopia, respectively. The result could reflect on the need for modernizing the marketing of crossbred cattle through supporting farmers to make performance records available (certification) and encouraging smallholder farmers for crossbred heifer production.

Table 2. Sources of crossbred cattle for foundation stock (N=243)

Sources	Frequency	Percent	Pr > ChiSq
Bought from market	72	29.63	
Gift (inherited from parent)	9	3.70	
Provided by a government institute	43	17.70	
Provided by a non-governmental organization	2	0.82	<.0001
Bought from commercial dairy farms	6	2.47	
Bought from surrounding farmers	62	25.51	
Crossing local cows	49	20.16	

N= Number of observations; Pr > ChiSq *indicates significance level between sources.*

Herd Characteristics and Structure

The proportion of farmers who owned indigenous cattle and herd structures across study Zones are presented in Tables 3 and 4. The result indicated that in addition to crossbred dairy cattle (as the study was conducted using farmers who had crossbred cattle); about 58% of farmers had indigenous cattle which significantly vary among Zones ($p < 0.001$). The majority of farmers (94.83%) in West Shewa own indigenous cattle. However, only 36% in NSHAMA and 48% in NSHORO kept indigenous cattle. Even, out of 143 farmers who own indigenous cattle only 39.86% had indigenous cows, 89.51% possess indigenous oxen and half of them kept only indigenous oxen (did not have indigenous cows, heifers or calves). Furthermore, about 49% of all respondents use crossbred oxen for traction purposes. The average herd sizes of indigenous and crossbred cattle were 2.02 and 6.89 heads per farmer, respectively. The number of crossbred cattle per household in the present study is close to 5.0 reported for Girar Jarso district (Tolera, 2017), but much higher than 0.32 in Aleta Chuko district (Kibru *et al.*, 2015), 1.00 in the Tigray Region (Destalem *et al.*, 2015), 1.88 in Arsi and Bale Zones (Mezgeb *et al.* 2017) in Ethiopia. The higher number of crossbred dairy cattle estimated in the present study compared to others in literature could be attributed to the special attention given to these areas by governmental and non-governmental organizations during the last 3-4 decades and sampling technique used as this study was conducted only on farmers who owned crossbred cattle. It can also indicate that this area has been specializing in crossbred production as 35% of the national crossbred population was found in these Zones (CSA, 2017).

Table 3. The proportion of farmers that keep indigenous cattle across study Zones (N=243)

Zone/type of cattle owned	No.	Frequency(%)	Pr > ChiSq
Arsi	62	36(58.06)	
NSHAMA	63	23(36.51)	
NSHORO	60	29(48.33)	<.0001
West Shewa	58	55(94.83)	
Overall	**243**	**143(58.83)**	
*Own indigenous cows	143	57(39.86)	0.0153
*Own indigenous oxen	143	128(89.51)	<.0001
*Own indigenous oxen only	143	72(50.35)	0.9334
Own crossbred oxen	243	119(48.97)	0.7484

N= Number of observations (interviewed farmers); NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; Pr > ChiSq *indicates significance level; * analysis was only on data from those farmers who had indigenous cattle.*

A significant difference ($p < 0.0001$) was detected between West Shewa and the other three Zones in total herd size and herd category of both indigenous and crossbred cattle. A considerably higher number of indigenous cattle (5.41) and a lower number of crossbred cattle (4.02) was recorded per household in West Shewa than the other studied Zones (0.65 to 1.16 for indigenous and 7.33 to 8.63 for crossbred). However, there was no significant difference ($p > 0.05$) observed between NSHAMA, NSHORO and Arsi Zones concerning average herd size and herd category. Farmers keep a higher proportion of crossbred cows (2.61) followed by heifers (1.21) and oxen (1.05). The result may infer that farmers were noticeably reducing the number of indigenous cattle and shifting to crossbred dairy cattle production. The farmers witnessed that they keep indigenous cattle mainly for traction purposes for one to two farming seasons and

then fatten and sell the oxen to generate income. It looks that farmers in West Shewa had lower experience for crossbred cattle production and gave more attention to other agricultural practices as they keep a relatively higher number of indigenous and fewer crossbred cattle.

Table 4. Average herd structure of crossbred dairy cattle and total indigenous cattle per household (N=243)

Type of crossbred	Overall	Zones				SL
		Arsi	NSHAMA	NSHORO	West Shewa	
Cow	2.61±0.10	2.65±0.19^{a}	3.10±0.19^{a}	2.88±0.20^{a}	1.78±0.20^{b}	***
Heifers	1.21±0.07	1.23±0.14^{a}	1.43±0.13^{a}	1.40±0.14^{a}	0.74±0.14^{b}	**
FC6-1	0.49±0.05	0.55±0.10	0.59±0.10	0.52±0.10	0.29±0.10	ns
FC<6	0.34±0.04	0.45±0.07	0.41±0.07	0.30±0.07	0.19±0.08	ns
MC6-1	0.53±0.05	0.50±0.09	0.62±0.09	0.62±±0.09	0.36±0.09	ns
MC<6	0.29±0.03	0.31±0.07	0.38±0.07	0.27±0.07	0.21±0.07	ns
Steer	0.16±0.03	0.15±0.06	0.14±0.06	0.20±0.07	0.14±0.07	ns
Bulls	0.22±0.03	0.32±0.07^{a}	0.38±0.07^{a}	0.12±0.07^{b}	0.05±0.07^{b}	**
Oxen	1.05±0.08	1.24±0.16^{ab}	1.59±0.16^{a}	1.03±0.16^{b}	0.26±0.16^{c}	***
Total cross	6.89±0.24	7.39±0.48^{a}	8.63±0.47^{a}	7.33±0.48^{a}	4.02±0.49^{b}	***
Total indigenous	2.02±0.14	1.16±0.28^{b}	0.65±0.28^{b}	1.08±0.29^{b}	5.41±0.29^{a}	***

*N= Number of observations; NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; SL= Significance level between Zones; FC6-1= Female calves between 6 months to 1 year age; FC<6 means female calves with less than 6 months; MC6-1= Male calves between 6 months to 1 year age; MC<6 means male calves with less than 6 months; *** means p < 0.0001; ** means p < 0.01; ns= Non-significant; Least squares means with the same superscript indicate non-significance (p > 0.05) between zones.*

Farmers Access and Preference for the Breeding Techniques

Tables 5 and 6 contain the breeding techniques used and preferences of smallholder dairy producers, respectively. Currently, about 51% of farmers use both artificial insemination (AI) and bull services for further genetic improvement and reproduction. They said that they use mainly AI and shift to bull service when AI is not available or when cows fail to conceive by AI. The proportion of farmers who use only bulls and AI were 26% and 23%, respectively. Thus, the results denote that the contribution of crossbred bulls was substantial in reducing the problems related to access and inefficiency of AI services in the rural and peri-urban areas as 77% of the dairy farmers were using bulls. In addition, it showed the lower efficiency and access to AI services. The use of bull may influence future genetic improvement and disease transmission if not selected based on breeding value and tested for sexually transmissible diseases. Consistent with our finding, Bebe *et al.* (2003) and Muia *et al.* (2011) reported a higher proportion (60- 62%) of dairy producers used bulls in Kenya. The use of breeding techniques was significantly differed ($p < 0.001$) among study Zones. Fifty percent of farmers in NSHAMA used only bulls compared to 12.5 -20% in the other studied Zones. The overall farmers' preference on breeding techniques indicated that 79% of farmers preferred AI and 21% choose bull services. There was a significant difference ($p < 0.05$) between Zones on the preference of breeding technique. Forty-four percent of farmers in NSHAMA prefer bulls whereas, an almost similar proportion (74-78%) of farmers in the other 3 Zones favor AI. This may infer the shift of farmers' preference from AI to bulls due to less efficiency and lack of access in NSHAMA. In addition, farmers in the other Zones had also complained about the availability, accessibility and efficiency of AI services.

Table 5. Breeding technique used for crossbreeding (N=241)

Breeding technique	Overall frequency (%)	Zones (%)				Pr > ChiSq
		Arsi	NSHAMA	NSHORO	West Shewa	
AI	55 (22.82)	13 (20.97)	1 (1.59)	18 (30.00)	23 (41.07)	
Bull	62 (25.73)	11 (17.74)	32 (50.79)	12 (20.00)	7 (12.50)	<.0001
Both	124 (51.45)	38 (61.29)	30 (47.62)	30 (50.00)	26 (46.43)	

N= Number of observations; AI= Artificial Insemination; NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; Pr > ChiSq *indicates a significance level between breeding techniques.*

Table 6. Preference of farmers for breeding technique (N=243)

Breeding technique	Overall frequency (%)	Zones (%)				Pr > ChiSq
		Arsi	NSHAMA	NSHORO	West Shewa	
AI	172(70.78)	47(75.81)	35(55.56)	47(78.33)	43(74.14)	0.0204
Bull	71(29.22)	15(24.19)	28(44.44)	13(21.67)	15(25.86)	

N= Number of observations; AI= Artificial insemination; NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; Pr > ChiSq *indicates significance level between breeding techniques preference between zones.*

Breeding Goal of Farmers for Crossbred Dairy Cattle

The primary objective of farmers to keep indigenous cattle is draught power followed by milk and beef with an index of 0.48, 0.28 and 0.24 respectively. Whereas they provide a high index for milk (0.5) followed by draught (0.26) and beef (0.24) as reasons for rearing crossbred cattle (Table 7). This could reflect that in addition to family nutrition and income generation, crossbred cattle considerably contribute to crop production. It also shows that even though more attention is provided for dairying, draught power is still important for farmers engaged in crossbred production in rural and peri-urban areas. This is consistent with other studies in the tropical countries which concluded that farmers keep indigenous and crossbred cattle for multiple objectives (Mwacharo and Drucker, 2005; Zewdu *et al*., 2006; Traore *et al.,* 2016). As shown in Table 8, farmers ranked better milk yield, market value and fast growth as the main reason to prefer crossbred than indigenous with an index of 0.41, 0.26 and 0.22 respectively. Belay and Janssens (2016) and Bebe *et al.* (2003) similarly noted that smallholder farmers keep crossbred mainly because of the higher milk yield potential of crossbred to generate more income.

Farmers were also asked to choose their breeding goal (dairy or dual, dairy and beef) for the future genetic improvement program. Significantly higher ($p < 0.0001$) proportion of farmers (75.52%) choose dairy as the primary goal and the other 24.48% favor dual-purpose across study sites (Table 9). There was no significant difference ($p > 0.05$) observed among Zones on breeding goal preference. This can point out that farmers provide more attention to dairy traits than beef and, therefore, a similar breeding program can be developed for these four Zones.

Table 7. Frequency and rank of breeding objective provided by farmers to keep indigenous and crossbred cattle (N= 15 farmers group discussions)

Objectives	Indigenous				Crossbred			
	Rank1	Rank2	Rank3	index	Rank1	Rank2	Rank3	index
Milk	2	6	7	0.28	15	0	0	0.5
Meat	0	7	8	0.24	0	7	8	0.24
Draught	13	2	0	0.48	0	8	7	0.26

N= Number of observations.

Table 8. Ranking of reasons why farmers prefer, keep and expand crossbred dairy cattle (N=243)

Factors	Rank1	Rank2	Rank3	Rank4	Index
Better Milk yield	234	6	3	0	0.41
Fast growth	6	67	131	26	0.22
Shorter calving interval	0	17	42	136	0.11
High market value	5	149	53	30	0.26

N= Number of observations.

Table 9. Breeding goal preference of farmers for future genetic improvement (N=241)

Type of breeding goal	Frequency (%)	*Pr > ChiSq	Zones (%)				**Pr > ChiSq
			Arsi	NSHAMA	NSHORO	West Shewa	
Dairy	182 (75.52)	<.0001	45(72.58)	46 (74.19)	46 (76.67)	45 (78.95)	0.8605
Dual	59 (24.48)		17 (27.42)	16 (25.81)	14 (23.33)	12 (21.05)	

*N= Number of observations; *Pr > ChiSq indicates significance level between breeding goals (rows); NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; **Pr > ChiSq indicate significance level between zones (column).*

Performance of Crossbred Cattle under Farmers Management Condition

As presented in Table 10, the least square means and standard error of DMY, AFC and CI performances of crossbred dairy cattle were 11.28±0.24 liters, 2.96±0.04 years and 1.32±0.02 years, respectively. The value of DMY observed in the present study is almost similar with 11.5 kg estimated for crossbred cattle in Sudan (Amasaib *et al*., 2011) and comparable to 9.4 kg for Friesian cows in Ethiopia (Million and Tadele, 2003). However, it was higher than 6.9 kg studied for crossbred in Tanzania (Bee *et al*., 2006), 6.7 for crossbred cows (Million and Tadele, 2003), and 6.9 kg for crossbred cows in Ethiopia (Kefale *et al*., 2019a).

The difference observed with other literature could be due to the difference in the size of data, breed and method of data collection as we consider recall methods which could vary with data collected at research stations. There was a significant difference ($p < 0.0001$) between Zones in DMY. Crossbred cattle in NSHORO (12.93±0.48) perform better than that of Arsi (10.81±0.47) and West Shewa Zones (9.37±0.50). Similarly, significantly higher ($p < 0.05$) CI was recorded in West Shewa Zone (1.45±0.05 years) than Arsi (1.31±0.04 years) and NSHORO (1.26±0.04 years). The value of CI found in the present study (482 days) is also close to 481 days estimated for Friesian x Boran crossbred cows (Kefena *et al*., 2006), 476 days for crossbred (Kefale *et al*., 2019b), and 497 days for Jersey cows in Ethiopia (Direba *et al*., 2015).

Crossbred cows gave their first calve at about 3 years ranging from 2.87 in Arsi Zone and 3.02 in West Shewa Zone. However, there was no significant difference ($p > 0.05$) detected between Zones. The Average AFC estimated here (35.5 months) is comparable with the study of Kefale *et al.* (2019b), Mezgeb *et al.* (2017) and Kefena *et al.* (2006) who found 37 months for crossbred in central Ethiopia, 33 months for indigenous cattle in Arsi and 34 months for crossbred cattle in central Ethiopia, respectively.

The overall lower performance of crossbred cows in West Shewa compared to the other three Zones might be due to the type of crossbred owned, experience related to husbandry practices and attention of farmers for farming practices. It looks that farmers in West Shewa had lower experience and gave more attention to other agricultural practices. In general, farmers were encouraged with the performance of crossbred cattle and 98.77% of the respondents were interested to continue with and expand the dairy business.

Table 10. Least square means and standard error estimated for the performance of crossbred dairy cattle across study Zones

Zone	DMY (N=240)	AFC (N=200)	CI (N= 217)
	***	ns	*
Arsi	10.81±0.47^{b}	2.87±0.07	1.31±0.04^{b}
NSHAMA	11.83±0.47^{ab}	2.96±0.07	1.33±0.04^{ab}
NSHORO	12.93±0.48^{a}	3.01±0.07	1.26±0.04^{b}
West Shewa	9.37±0.50^{c}	3.02±0.11	1.45±0.05^{a}
Overall mean	11.28±0.24	2.96±0.04	1.32±0.02

*N= Number of observations; NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; DMY= Daily milk yield; AFC= Age at first calving; CI= Calving interval; ***p < 0.0001; ns= Non-significant; *p < 0.05; Least squares means with the same superscript indicate non-significance (p > 0.05) between zones (rows).*

Weight of Importance for Selection Criteria and Dairy Traits

Due to the absence of a recording system for breed evaluation and selection in the rural and peri-urban areas of Ethiopia, farmers have been using their own selection criteria to purchase or select crossbred dairy cattle for future reproduction and improvement. Group discussion composed of 8-12 farmers in each selected *kebele* (a total of 15 FGD across study sites) were arranged to provide weight (out of hundred) for major traits of dairy cattle and selection criteria for cows and bulls.

As shown in Table 11, farmers provided the highest attention for milk yield (28.13±1.04%) followed by body conformation (20.07±0.87%) and udder size and set up (18.73±0.90%). Similarly, they gave the highest weight for milk yield, body conformation and size of the scrotum for the selection of bulls with a weight of 28.13±1.51%, 22.40±0.84% and 16.13±1.05%, respectively (Table 12). The respondent said that they ask milk yield of cows or relatives of bulls during purchasing or choosing bull for mating. The temperament of cows and bulls has got better weight than color and tail size for cows and bulls evaluation and selection. The result is consistent with the finding of Destalem *et al.* (2015) and Wurzinger *et al.* (2006) who ranked milk yield, fertility and body size as the most important trait for crossbred dairy cattle in Northern Ethiopia and Ankole cattle breed in Burundi Rwanda, Uganda and Tanzania, respectively. Chawala *et al.* (2019) has also discussed that farmers ranked milk yield as priority traits followed by fertility and temperament in Tanzania.

There was no significant difference ($p > 0.05$) detected among study Zones for all traits except the temperament of bulls. Farmers in West Shewa (18.00±2.03%) and NSHORO (16.75±1.75%) provide significantly higher ($p < 0.05$) weight for temperament than those in Arsi (11.00±1.75%) and NSHAMA (10.75±1.75%). In literature, body conformation traits (body width and height, rump, leg length and neck) have a low genetic correlation with milk yield and quality but a favorable correlation with health, fertility and longevity of dairy cows (Haas *et al*., 2007; Strapak *et al*., 2010; Fuente *et al*., 2011) indicating the need for considering them in the selection index and use as an option for a community-based breeding program.

Further analysis of the relative importance of growth, milk yield, reproduction and longevity traits was shown in Table 13. The average weights provided by FGD for milk yield (MY), calf growth (CG), AFC, CI and herd life were 29.73%, 18.53%, 17.80%, 19.60% and 14.40%, respectively. The traits most weighted by farmers were MY and CI followed by CG and AFC indicating that farmers need high-yielding cows for income generation and successive reproduction for a

continuous supply of milk, sale of crossbred cattle and herd replacement. This is in agreement with other studies in the tropics (Lanyasunya *et al*., 2006; Stein *et al*., 2009; Takele *et al*., 2011). For instance, Chawala *et al*. (2019) weighted milk yield, fertility and temperament as the most important trait for crossbred dairy cattle in Tanzania. Similarly, Belay and Janssens (2016) found close value to that of our estimate that farmers ranked milk yield (index = 0.25) as the most preferred trait followed by fertility (0.23), lactation length (0.22), longevity (0.14) and growth rate (0.12) in western Ethiopia. There was no significant difference ($p > 0.05$) in weighing traits across study Zones. This could reflect that dairy farmers across all study sites had a similar perception on the relative importance of different traits. In addition, the weight provided for each trait will help to consider the interest of farmers and estimate the economic value required to design a breeding program.

Table 11. Importance weight (percentage and standard error) for selection criteria set up by farmers group discussion for cows selection (N= 15 farmers group discussions)

Zone*	MY	Conformation	Tail	Udder	Color	Temperament
Arsi	27.75±2.01	20.75±1.69	8.75±1.3	18.00±1.74	9.50±1.49	15.25±1.38
NSHAMA	28.25±2.01	22.50±1.69	6.75±1.3	18.25±1.74	9.75±1.49	14.50±1.38
NSHORO	28.50±2.01	18.75±1.69	8.50±1.3	18.00±1.74	9.75±1.49	16.50±1.38
West Shewa	28.00±2.33	17.67±1.95	7.67±1.5	21.33±2.01	8.67±1.72	16.67±1.59
Overall	28.13±1.04	20.07±0.87	7.93±0.67	18.73±0.90	9.47±0.77	15.67±0.71

*N= Number of observations; * indicates no significant difference between zones (p > 0.05); NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; MY= Milk yield.*

Table 12. Importance weight (percentage and standard error) for selection criteria set up by farmers group discussion for bulls selection (N= 15 farmers group discussions)

Zone	MY	Conformation	Tail	Scrotum	Color	Temperament
	ns	ns	ns	ns	ns	*
Arsi	31.25±2.92	23.25±1.63	10.25±2.13	14.50±2.04	9.75±1.63	11.00±1.75[b]
NSHAMA	27.75±2.92	25.50±1.63	8.25±2.13	18.50±2.04	9.25±1.63	10.75±1.75[b]
NSHORO	26.25±2.92	20.75±1.63	9.75±2.13	16.00±2.04	10.50±1.63	16.75±1.75[a]
West Shewa	27.00±3.37	19.33±1.88	11.33±2.46	15.33±2.35	9.00±1.88	18.00±2.03[a]
Overall	28.13±1.51	22.40±0.84	9.80±1.10	16.13±1.05	9.67±0.84	13.87±0.91

*N= Number of observations; NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; MY= Milk yield; ns= Non-significant; * indicates P < 0.05; Least squares means with the same superscript indicate non-significance (p > 0.05) between zones.*

Table 13. Weight of importance (percentage and standard error) set up for dairy traits by farmers group discussion (N= 15 farmers group discussions)

Zone*	MY	CG	AFC	CI	HL
Arsi	31.25±2.93	17.75±1.27	17.50±1.79	19.75±2.85	13.75±2.29
NSHAMA	27.50±2.93	21.00±1.27	17.50±1.79	18.25±2.85	15.75±2.29
NSHORO	28.25±2.93	17.00±1.27	17.75±1.79	21.50±2.85	15.75±2.29
West Shewa	32.67±3.38	18.33±1.47	18.67±2.07	18.66±3.29	11.67±2.65
Overall	29.73±1.51	18.53±0.66	17.80±0.93	19.60±1.47	14.40±1.18

*N= Number of observations; * indicates no significant difference between zones (p > 0.05); NSHAMA= North Shewa Zone of Amhara Region; NSHORO= North Shewa Zone of Oromia Region; MY= Milk yield; CG= Calf growth; AFC= Age at first calving; CI= Calving interval; HL= Herd life.*

Conclusion

More than half of farmers in the study areas started the business of rearing crossbred cattle based on purchased animals which shows the need for improving the marketing of breeding cattle. The higher number of crossbred dairy cattle in the present study areas compared to other areas indicate that farmers in these areas have been specializing in crossbred production. Based on this observation, the researchers assumed that the areas can serve as a source of genetic pool for the crossbred cattle. Besides family nutrition and income generation, crossbred cattle have considerably supported crop production. The contribution of crossbred bulls was substantial in reducing the problems related to access and inefficiency of AI services in the rural and peri-urban areas as 77% of the dairy farmers use bulls. The use of bulls may influence future genetic improvement and disease transmission if not selected based on breeding value and tested for sexually transmissible disease. In general, farmers were encouraged by the performance of crossbred cattle and had interests in expanding the dairy business. The result can point out that most farmers across all study Zones gave more preference to dairy traits than beef. Most of them had similar perception on the relative

importance of different traits indicating the possibility to develop a similar breeding program throughout the study areas. In designing a breeding program in the future, the weight given for each trait in this study need to be considered. Improvement of AI service, access to marketing of crossbred cattle and design of appropriate breeding programs are essential for the development of this sector in the future.

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Conflict of Interests

The authors declare that they have no competing interests.

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